Advanced Electrical Materials and Components Being Developed

All aerospace systems require power management and distribution (PMAD) between the energy and power source and the loads. The PMAD subsystem can be broadly described as the conditioning and control of unregulated power from the energy source and its transmission to a power bus for distribution to the intended loads. All power and control circuits for PMAD require electrical components for switching, energy storage, voltage-to-current transformation, filtering, regulation, protection, and isolation. Advanced electrical materials and com-ponent development technology is a key technology to increasing the power density, efficiency, reliability, and operating temperature of the PMAD.

The primary means to develop advanced electrical components is to develop new and/or significantly improved electronic materials for capacitors, magnetic components, and semiconductor switches and diodes. The next important step is to develop the processing techniques to fabricate electrical and electronic com-ponents that exceed the specifications of presently available state-of-the-art components. The NASA Glenn Research Center's advanced electrical materials and component development technology task is focused on the following three areas:

1. New and/or improved dielectric materials for the development of power capacitors with increased capacitance volumetric efficiency, energy density, and operating temperature.

2. New and/or improved high-frequency, high-temperature soft magnetic materials for the development of transformers and inductors with increased power density, energy density, electrical efficiency, and operating temperature.

3. Packaged high-temperature, high-power density, high-voltage, and low-loss SiC diodes and switches.

The accomplishments for each of these areas follow:

For the power capacitor area, candidate high-temperature ceramic dielectrics with dielectric and electrical properties suitable for use up to 300 °C were identified and evaluated along with dopant materials that increased the bulk resistivity and decreased the average grain size in the fired, multilayer ceramic capacitors (MLCCs). In addition, MLCCs of different compositions and sizes were fabricated, tested, and evaluated using the candidate dielectric and dopant materials that exhibited the best dielectric (dielectric constant) and electrical (resistivity and dielectric strength) properties for long-term, high-temperature use. The capability to deposit up to 25 ft of wrinkle-free diamondlike-carbon (DLC) film on both sides of aluminum foil was demonstrated for capacitor construction. Five different types of aluminum foils, two different types of metalized polymer films, and three different types of polymer films were demonstrated as substrates for diamondlike-carbon films and were evaluated in terms of surface roughness, adhesion, wrinkle-free characteristics, and film thickness and uniformity.

In the magnetic materials research area, Glenn's core loss and dynamic hysteresis loop measurement system was upgraded to measure the electrical and magnetic characteristics of high quality factor (*Q*) inductor-type magnetic materials. These core loss tests were conducted on $Co_{50}(SiO_2)_{50}$ and $(Fe_{50}Ni_{50})_{90}(SiO_2)$ nanocomposite magnetic materials at room temperature over frequencies ranging from 100 kHz to 1 MHz. In addition, a 2.5-kVA/kg, 200 °C transformer was demonstrated. Compacted, noncoated Ni Fe nanoparticles were investigated extensively to study the magnetic-moment-exchange coupling mechanism, and the physical and direct-current magnetic properties of seven soft, magnetic, FeCo-based nanocrystalline alloys were designed, processed, fabricated, and characterized.

In the semiconductor switch and diode area, experimental methods and procedures were investigated for measuring the dynamic characteristics of Si, GaA, and SiC Schottky diodes. The room-temperature current-voltage characteristics of Si, GaA, and SiC Schottky diodes with similar rated Si pn junction diodes were investigated for comparative purposes, and the effects of NO passivation on the radiation responses of gate oxides for 4H-SiC power MOSFETS were investigated. High-quality GaN and AlGaN/GaN epitaxial films were grown on SiC and sapphire substrates using metal organic vapor deposition, and the growth of defect-free 3C-SiC on 4H- and 6H-SiC mesas was demonstrated using step-free surface heteroepitaxy.

Find out more about this research: http://powerweb.grc.nasa.gov/elecsys/

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